ESTABLISHMENT OF WARM AND COOL SEASON GRASS PASTURES ON WOODED SITES IN EAST CENTRAL OKLAHOMA AFTER AERIAL SPRAYING AND BURNING

By

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CHAPTER I

INTRODUCTION

There is a definite need in Oklahoma for year round pasture programs for cattle. Eastern Oklahoma has millions of acres that are capable of providing this forage if managed correctly. These potentially high producing areas are today covered with low value hardwoods. While the main objective is to kill the hardwoods and thereby increase growth of grass for livestock, the spraying also affects browse and forbs of value to deer. In recent years research has been initiated on these unproductive sites in an effort to change low producing brush covered sites into high quality pastures. To accomplish this, a combination of spraying, controlled burning, aerial fertilization, and aerial seeding practices have been followed. Practices similar to these have been used in Missouri and Arkansas on similar sites with varying degrees of success (Crawford and Bjugstad, 1967; Ray, 1958).

Several problems have developed during the process of converting these low value brush covered sites into productive permanent pasture. Resprouting from post oak (*Quercus stellata* Wing.) and blackjack oak (*Q. marilandica* Muenchh.), along with resistant secondary woody species has brought about a decline in the quality and productiveness of an established pasture. Broomsedge (*Andropogon virginicus* L.) has slowed establishment of improved species by out competing these introduced species for the sometimes limited amounts of available soil moisture.

The natural low fertility of the area necessitates the application of fertilizer shortly before or at the time of seeding in order to insure success of the stand.

It is hoped that solutions can be provided for these obstacles and that a management technique can be better defined through the work and efforts put forth in this study.

Although many different methods of brush control and grass stand establishment have been evaluated, no single method has yet been determined best suited for Eastern Oklahoma. Natural fertility, soil physical characteristics, native plant species present, as well as a host of other interrelated factors, make Eastern Oklahoma unique from areas in Missouri and Arkansas where many investigations of this type have been carried out. Therefore, more research is needed in Eastern Oklahoma where establishment of grass following herbicide treatment on rough brushy rangeland is being attempted.

The objectives of these studies were to: evaluate three warm season grass species seeded in June immediately following spraying and using various fertilizer treatments; evaluate three cool season grass species seeded in the fall with various fertilizer treatments on an area sprayed in a previous year and now having a healthy native grass recovery; and measure this native grass response to nitrogen and phosphorus fertilizer in dry matter production, crude protein content, and phosphorus content.

CHAPTER II

LITERATURE REVIEW

Chemical Control

Various methods have been used in attempting to remove low value oaks for the release of grass in Eastern Oklahoma and elsewhere. Mechanical removal and burning have been tried with little success due to the resprout from the base of the stems (Elwell et al., 1970; Lillie et al., 1969).

With the introduction of phenoxy herbicides, some degree of success has been obtained in brush control according to Elwell (1968), in a brief history of (2,4-dichlorophenoxy) acetic acid (2,4-D) and its use in brush control. Elwell stated that 2,4-D was first used in experiments in June 1945. In 1954 applicators began using 2,4-D along with other phenoxy herbicides with aerial applications on a larger scale. This program expanded until today about 200,000 acres are treated annually in Oklahoma. Elwell concluded that farmers and ranchers, with proper use of herbicides, could control low value post and blackjack oak and increase native grass production on thousands of acres in Oklahoma, Kansas, Missouri, Arkansas, and Texas.

The optimum time of applying a phenoxy herbicide to obtain maximum control of brush has been evaluated (Eaton, 1968; Elwell, 1964; Meyer et al., 1970; Ray, 1958; Rommann et al., 1974). All generally agreed that the best time to spray was when the tree was growing actively with sufficient soil moisture.

The best brush control (canopy reduction and % kill) in Oklahoma resulted when sprayings were done in a good rainfall year following dry years (Stritzke, 1974; Elwell et al. 1974). The worst brush control resulted following good rainfall years.

Meyer et al. (1970), hypothesized two possible reasons for April and May applications in East Texas being superior for brush control: (1) the trees might have been more physiologically active in the spring than in the fall; and (2) the herbicide would more likely be leached into the root zone before breaking down in the cooler rainy spring period than in the warmer, drier summer period.

Ray (1958) added that in Arkansas it was important to spray when the leaves were fully developed and beginning to manufacture food materials in excess of the requirements for growth. Application made too early would burn the leaves but would not kill the plant, while applications made too late in the summer after the growth had slowed were not as effective.

There are many factors which influence control of woody plants with phenoxy herbicides besides the ones previously mentioned. Rommann et al. (1974) listed five of these: (1) fire before herbicide treatments has often caused ineffective control, and spray treatment should be delayed one year if a fire has occurred, (2) optimum temperature appeared to be 60 to 80 F for effective spray applications, (3) high humidity at the time of spraying favored longer absorption time by the leaves, (4) wind was a detrimental factor by causing herbicide to drift and therefore, should be less than five mph at time of spraying, and

(5) uniform application was a must. Eaton et al. (1968) added that the amount of moisture on the oak foliage and the total rainfall during the month prior to spray application was significantly correlated with defoliation of oaks by (2,4,5-trichlorophenoxy) acetic acid (2,4,5-T). Better brush control has been consistently obtained on soils having a lower site index rating than on soils with a higher site rating (Ray, 1958).

Eaton et al. (1968) and Elwell (1964) have found that the general types of fixed wing aircraft used for aerial application had no influence on oak defoliation following a treatment. Nichols et al. (1971) reported no difference between the effectiveness of an airplane or helicopter.

The phenoxy herbicides are selective to some degree and certain results can be expected for different herbicides applied. Elwell (1964) found that 2,4,5-T was slightly more effective than 2-(2,4,5-Trichlorophenoxy) propionic acid (Silvex) on mixed stands of post, blackjack, and chinquapin oaks (Quercus meuhlenbergii Engelm.) and associated species. Silvex has generally been slightly more effective on post oak. Oak control was erratic with 2,4-D.

Meyer et al. (1970) found that mixtures of 2,4,5-T plus 4-amino-3,5,6-trichloropicolinic acid (Picloram) were the most effective overall treatments per pound of herbicide for the East Texas timberland area. Picloram was the most effective individual chemical in that it controlled the most woody species. These same conclusions were supported by Rommann et al. (1974), and the addition of ammonium thiocyanate in a mixture of Silvex or 2,4,5-T has increased the effectiveness of that herbicide on winged elm (Ulmus alata Michx.).

A large amount of information has been collected documenting the increase in herbage production following release of grass through brush control (Dalrymple et al., 1964; Davis, 1967; Ehrenreich and Crosby, 1960; Elwell, 1964; Elwell, 1968; Elwell et al., 1970; Halls and Crawford, 1965; Meyer et al., 1970; Ray, 1958; Rommann et al., 1974). These workers have agreed that herbicide control of woody species has greatly increased herbage production. This increase was shown to vary considerably depending on site, species present, etc.

Ray (1958) found that native grass production may increase as high as 600 percent on some sites. Halls and Crawford (1965) found that aerial spraying of woodland with 2,4,5-T temporarily increased production of grasses preferred by cattle. Then, a reinvasion of woody plants and heavy grazing by cattle contributed to the subsequent decline in grass yields. The invading shrubs included many species preferred by deer. Davis (1967) indicated that broomsedge became abundant in a natural seeded area in Arkansas after spraying. In the fourth year little bluestem (*Andropogon scoparius* Michx.) became abundant but was seriously damaged by heavy grazing and fire. Five years after spraying, sprouts and shrubs began invading and competing with the grass.

Reports by Rommann et al. (1974) revealed that the establishment of tall fescue (*Festuca arundinacea* Schreb.) in Eastern Oklahoma has been successful in sprayed areas.

Nichols et al. (1971) suggested that any soil with reasonably good depth and waterholding capacity might be seeded to a cool season grass, such as tall fescue, or a warm season species.

Crawford and Bjugstad (1967) suggested spraying, burning, seeding, and fertilizing because areas sprayed and allowed to seed naturally produced little desirable grass.

Other implications regarding herbicide brush control are often overlooked but could be of importance. Rapid growth and tillering of bunch grasses following treatments with phenoxy herbicides has caused farmers to believe that chemicals stimulate grasses like fertilizer (Elwell, 1968). He reported that chemical analysis of several grass species for nitrogen and soluble salts revealed very little difference between 2,4,5-T and Silvex treated and untreated areas.

Halls and Crawford (1965) suggested the possibility of using herbicides to improve deer habitat. They furthermore stated that if this was the main consideration spraying should be done on a less frequent basis and in alternate strips or blocks. This would create more of an edge effect and the invading shrubs could be utilized as browse.

Dalrymple (1964) and Elwell et al. (1970) have shown soil moisture to be significantly higher in herbicide treated plots than in the untreated ones.

Spraying wooded range with herbicides resulted in a more complete and permanent release of herbaceous vegetation than could be obtained by burning or mechanical treatments (Elwell et al., 1970; Ehrenreich and Crosby, 1960; Lillie et al., 1969).

Burning

The effects of fire on native grass production have not always been the same. Extensive studies in Kansas have shown that burning has detrimental effects on forage yields (Aldous, 1934; Anderson, 1964; Anderson, 1965; Anderson et al., 1970; Hopkins et al., 1948; Launchbaugh, 1964; McMurphy and Anderson, 1963; McMurphy and Anderson, 1965; Owensby and Anderson, 1965; Smith et al., 1964). Klett et al. (1971) found that burning reduced weeping lovegrass [*Evagrostis curvula* (Schrad.) Nees] production in Texas.

However, Owensby et al. (1970) reported that burning big bluestem (*Andropogon gerardi* Vitman.) range in Kansas increased forage yields. Ehrenreich and Aikman (1963) and Kucera and Ehrenreich (1962) in Iowa and Missouri, respectively, found that forage production could be increased by burning native prairie. This response was attributed directly to litter removal (Grelan and Epps, 1967).

These seemingly contradictory results could possibly be explained by the effects of burning on soil moisture. Kucera et al. (1967) suggested that beneficial effects of fire on prairie could be expected only where the precipitation was dependable and exceeded 18 inches annually. Lower soil moisture following burning was reported by Anderson (1965); Ehrenreich and Aikman (1963); Hopkins et al. (1948); Launchbaugh (1964); and McMurphy and Anderson (1963). Where rainfall was inadequate and soil moisture was limited it seems reasonable to assume that burning could reduce forage production. Reduction in soil moisture was associated with decreased infiltration rates as shown by Hanks and Anderson (1957). Substantial loss of moisture as well as soil erosion following burning has been reported by Elwell et al. (1941).

Higher soil temperatures on burned pastures have also contributed to the soil moisture reduction (Ehrenreich and Aikman, 1963; Aldous, 1934; Kucera and Ehrenreich, 1962; Morris, 1968). Enrenreich and Aikman (1963) showed that soil temperature was higher on burned than on unburned areas at all depths until July or August. During May and early June midday soil temperature at the 0.5 inch depth was as much as 10 F higher on the burned areas than on unburned areas. By July shade from the vegetation was almost as effective as the litter mulch in reducing soil temperature, and there was little difference between burned and unburned areas. Burning generally resulted in earlier vegetative growth.

Two possible reasons for less soil moisture on a burned area as compared to an unburned area have been shown to be (1) greater transpiration from the earlier developed vegetation and (2) a higher rate of evaporation from the soil surface caused by higher soil temperatures and increased exposure on burned areas.

The effects of fire on the plant species of the community are many. Kucera and Koelling (1964) found that annual spring burning in Missouri maintained dominance of the native warm season grasses. Non-grass species, particularly composites, became less prevalent compared to unburned plots on which the grasses showed a noticable decline.

Graves and McMurphy (1968) showed that burning in Oklahoma resulted in composition changes toward more of the desirable decreaser species and fewer of the undesirable annuals. Martin and Cosby (1955), while burning in Missouri glades, found a direct contrast to this when they combined the effects of drought, fire, and overgrazing. They noted a very conspicuous increase in such annual weeds as croton (Croton spp. L.), ragweed (Ambrosia artemisiifolia L.), and palafoxia [Palafoxia callosa (nutt.) T. & G.] on the glade range. The frequency of little bluestem declined by 15 percent on the grazed areas, 30 percent on the burned areas, and 75 percent on the areas that were both grazed and burned.

Pase (1971) found that a rapidly moving fire that resulted from dry grass was quite effective in topkilling shrubs (up to 18 percent kill). When a wildfire swept the Wichita Mountains Wildlife Refuge, Penfound (1968) reported that much of the predominant Andropogon was destroyed. Invader species gradually returned to the area. Hopkins et al. (1948) has shown that, where litter accumulations were heavy at the time of burning, damage was severe and the ground cover of living vegetation and subsequent yields were greatly reduced.

Most of the effects attributed to burning were due to the removal of residue from the soil surface and its effects on the soil fertility. Conflicting reports have been documented regarding the effects of fire upon the organic matter and nitrogen content of a soil.

Morris (1968) found that burning of bahiagrass (Paspalum notatum Flugge) sod did not affect the soil organic matter and nitrogen content over a three year period. Valamis and Gowans (1961) showed that burning increased the available nitrogen in the soil. The results were less pronounced over a two year burn than over a one year burn. Comparable work by Mayland (1967) also revealed that nitrogen availability was higher on soils from burned areas than from unburned areas 10 months after burning. Elwell et al. (1941) stated that fire releases into the air the nitrogen contained in the vegetation which the plants originally took from the soil. They also noted that burning reduced the productiveness of pasture soil by rapidly oxidizing the partially decomposed organic matter and placing the ash minerals contained in the vegetation in a form which may be readily removed by leaching and erosion. This could account for the short term effect of decreased carbon and a lower C:N ratio thereby allowing an increased nitrogen availability after burning.

Ehrenreich and Aikman (1963) have shown while burning Iowa prairie that burning has had no apparent effect on the amount of exchangeable potassium, but available phosphorus was increased. There was more available phosphorus in the top 0.75 inches of soil on recently burned areas than on unburned areas.

Valamis and Gowans (1961) speculated that the application of fertilizer directly after burning may be unnecessary. It could be more useful to apply fertilizer the following year after the stimulating effects of the burn have disappeared. They noted that burning of vegetation caused an increase in the supply of nitrogen, phosphorus, sulfur, and a rise in soil pH. Mayland (1967); Ehrenreich and Aikman (1963); and Marshall and Averill (1928) also confirmed the report by Valamis that burning does cause an increase in soil pH.

Seeding and Establishment

Burma (1970) observed that the results of a rough wooded area aerially sprayed and successfully seeded to a productive grass species were: (1) reduced soil erosion; (2) increased carrying capacity for livestock and wildlife; (3) reduced fire hazard; (4) increased groundwater supply; and (5) better accessibility for livestock management and recreation. Success of a seeded area is not always guaranteed, however. There are several requirements to be filled before a successful stand will be established when aerially broadcasting seed upon a rough unprepared soil surface. The requirements for successful aerial seeding of pasture according to Campbell (1968) were: (1) reliable and effective rainfall; (2) low temperatures and evaporation; and (3) soil surfaces frequently wet by rain, snow, dew, frost, or mist. Conditions such as these do occur in Eastern Oklahoma.

Conditions for establishment of seed on the soil surface were more severe than those experienced by buried seed according to Meeklah (1958) and Evans et al. (1967). The reasons cited by them were due to rapid fluctuation in moisture and humidity in the micro environment of the seed at the soil-air interface, which resulted in unfavorable conditions for germination. The radicles of exposed seeds have had difficulty in penetrating the soil surface and elongating rapidly enough to keep pace with the receding moisture front. Finally, as with all forms of establishment, success depended on the ability of the young seedling to become fully autotrophic and to resist the stresses imposed by the environment and other competing vegetation.

Dowling et al. (1971) summarized the following five points concerning seedling establishment: (1) both the establishment and survival of seedlings sown by broadcasting on to non-arable land can be significantly improved by a prior treatment of the site with herbicides to reduce competition from existing vegetation, (2) providing protection for seeds by retaining dead vegetative cover, or by creating some form of surface roughness, has improved establishment as it reduced desication and provided a more favorable microclimate in the vicinity of the seed, (3) uptake of water by seeds resting on the soil surface was enhanced by absorbent lime or bentonite coatings, (4) failure of radicles to penetrate the soil following germination was an important factor limiting the establishment of legumes on exposed sites, and any restraint on the movement of germinating seeds under those conditions improved the penetration of the radicle, and (5) variations between species in their ability to establish on the soil surface were shown. These points were supported in part by other reports (Ehrenreich and Crosby, 1960; Martin and Crosby, 1955; Nichols et al., 1971; Rommann et al., 1974; Wood and Kingsbury, 1971; McGinnies, 1960; Douglas et al., 1960; Plummer, 1943; Douglas et al., 1960; Plummer, 1943; Kingsbury, 1971).

Litter removal before seeding may be of utmost importance for the survival of sown young grass seedlings. Crawford and Bjugstad (1967) stated that the main objective of burning was to remove the dry leaf litter that prevented the light grass seed from reaching moist ground and germinating in a proper environment. Rommann et al. (1974) agreed with Crawford and Bjugstad, but added that fire was also important to weaken the stand of native grass in order to facilitate in establishment of introduced grass seeds. Nichols et al. (1971) substantiated the two previous viewpoints by stating that a controlled burn (one that burns the loose leaves but does not destroy the decayed leaf mulch underneath) made just prior to seeding was the most important step in obtaining adequate stands of forages. He furthermore added that the ashes provided an ideal seedbed and that the grass should be seeded just after burning as soon as the ashes have cooled and before a rain has fallen on the ashes.

Fertilization

The effects of fertilizer on the establishment of a grass species has met with variable results (Cosper and Alsayegh, 1964). Under droughty conditions starter fertilizer increased establishment of western wheatgrass (*Agropyron smithii* Rydb.) plants. However, with a more favorable moisture regime the fertilizer effect was negligible on the establishment of wheatgrass plants. They found that nitrogen fertilizer aided establishment under droughty conditions, but nitrogen plus phosphorus was a superior treatment.

Working in a high altitude park in Montana, where the annual precipitation was 25 inches, Gomm (1962) found that fertilizers probably reduced the number of established seedlings.

Hull (1963) found that fertilizer application did not significantly affect plant numbers. He found no difference in emergence, survival, vigor, or color of seeded or native plants. Earlier work by Hull et al. (1962) contradicted his 1963 findings. Several fertilizers were applied spring and fall for three years on new range seedings on six mountainous areas in the west where precipitation ranged from 12 to 40 inches annually. They found that nitrogen slightly increased numbers of seedlings at one location and increased vigor of seeded and native plants at most locations.

Welch et al. (1962), working in a low rainfall area of West Texas, has shown that fertilizer did not increase seedling emergence in any of the native grass species tested. Fertilizer increased the stand count of only one species in only one year. In Missouri and Oklahoma, Crawford et al. (1967) and Rommann et al. (1974) have suggested the use of a starter fertilizer to insure success of stand establishment of sown grasses on rough timbered land that is in the process of being converted to grass.

Timing of application of fertilizer has been found to be important. Warnes and Newell (1969) warned against nitrogen fertilization of warm season grasses for spring and summer establishment as it may deter stand development by increasing weed competition. Indescriminant use of follow up nitrogen fertilizer can be serious by increasing the competition from cool season grasses while warm season grasses are dormant. They concluded that proper fertilization is necessary for full success on problem soil sites with low organic matter, eroded slopes, or other areas where nutrient deficiencies occur. They also added that nitrogen fertilizer may be applied after the desired grass becomes dominant in the stand. Graves and McMurphy (1968) made similar conclusions from work they did in fertilizing a low producing range in Central Oklahoma. They found that undesirable grasses would respond to fertilizer so they must be controlled. Similar work by Huffine and Elder (1959) near Guthrie, Oklahoma, showed fertilization on unplowed-cleared land and eroded land caused a large increase in the number of weeds produced.

Cosper et al. (1967) and Nichols and McMurphy (1969) reported other changes in the vegetation composition as a result of fertilization. Nichols and McMurphy (1969) noted that nitrogen fertilization in combination with 2,4-D treatments increased the frequency and production of perennial grasses over the control. These effects were most pronounced three years after application. Combinations of these treatments were more effective than either of these treatments alone.

Effect of fertilizer on forage yield and quality of different cool season and warm season grasses has been well documented. Vogel and Peters (1961) found that areas seeded to Kentucky-31 tall fescue and lespedeza (Lespedeza spp. Michx.) resulted in a threefold increase in total yield of fescue and other desirable forage plants and a marked decrease in herbage production from the less desirable forage plants.

Fuller et al. (1971) found that tall fescue in Eastern Oklahoma can be a very productive grass if properly fertilized with nitrogen, phosphorus, and potassium. Crude protein content of nitrogen-fertilized tall fescue was much higher than unfertilized tall fescue. Rommann et al. (1974) suggested application of 50 lb/acre of actual nitrogen during February following seeding of tall fescue in rough, sprayed land in Eastern Oklahoma. They contended that this would encourage more vigorous development of the fescue plants and also allow them to fully mature. In addition, seed from these mature plants helped to fill in any thin stands.

In weeping lovegrass fertilization trials at Perkins, Oklahoma, McMurphy and Denman (1971) found that without nitrogen fertilization the production and crude protein of weeping lovegrass dropped to very low levels. They suggested that at least 80 lb nitrogen/acre should be used annually on lovegrass. They also found a definite response to phosphorus and possible potassium deficiencies at high levels of production. Some contradictory results have been shown regarding the use of fertilizer in the establishment of weeping lovegrass. Dalrymple (1972) suggested the use of starter fertilizer for promoting early stand development. He contended that all phases of growth from tillering to early forage and seed production were enhanced by proper starter fertilizer programs. Bryan and McMurphy (1968), on the other hand, found that fertilization with nitrogen and phosphorus did not increase the stand establishment of weeping lovegrass but it did significantly increase forage yields. This yield increase was comparable to results obtained by Thompson and Schaller (1960) when they studied the effects of fertilizer on weeping lovegrass in Oklahoma.

Fertilizer may affect seeding vigor and thus affect initial stand establishment as reported by Gomm (1962). In a greenhouse experiment fertilizer did not affect vigor before seedlings reached the second leaf state. By the third leaf stage, seedlings in the experiment averaged 2.7 inches taller in the fertilized than in the unfertilized treatment. Seedling vigor is species dependent and the effect of fertilizer on each grass species may be different (Gullakson et al., 1964; Welch et al., 1962). The former also found that: (1) without fertilizer tall fescue had the greatest seedling vigor when compared with Caucasian bluestem (Andropogon intermedius R. Brown) and switchgrass (Panicum virgatum L.), (2) with fertilizer Caucasian bluestem had the greatest seedling vigor after the 22nd day of the experiment, and (3) the growth of Caucasian bluestem was repressed relatively more by adverse physical and/or chemical properties of a soil even when nitrogen, phosphorus, and potassium were added than was the growth of the other two species.

Thompson and Schaller (1960) found that grasses having strong seedling vigor, such as weeping lovegrass, blue panicgrass (Panicum antidotale Retz.), and Caddo switchgrass, responded to starter fertilizer. Warnes and Newell (1969) have found the superior seedling vigor of some late maturing warm season grass strains to be good competitors with weeds and thus capable of producing better stands than the earlier maturing species with lower seeding vigor.

Fertilizer did not have any effect upon seedling emergence, but weed competition did reduce seedling emergence in one species (Welch et al., 1962). Hull (1963) has reported similar observations.

CHAPTER III

MATERIALS AND METHODS

Land Resource Area

Hughes County lies in the southern part of the Great Plains in East Central Oklahoma. Elevation is about 900 feet. The climate is warm-temperate and subhumid. Season changes are gradual, but seasonal characteristics are well defined. The average annual temperature based on records from 1931 to 1960 was 61.4 F (Appendix Table XI). The average monthly temperatures range from 41.8 in January to 83.9 F in August. The average length of frost free days each year is about 220 days with the first fall frost occurring in October and the last spring frost occurring in April (U.S. Dept. of Commerce, 1965).

The average annual precipitation is 42 inches (Appendix Table XII). About half of the rain falls during the summer growing season, with May being the wettest month and January being the driest.

About 40 percent of Hughes County is in native range. Another 50 percent of the area has woody cover of low quality as a result of fires, close grazing, and clear cutting of commercial species (Long, 1968).

Study Area Description

The study area (Figure 1) is located two miles east of Lamar,

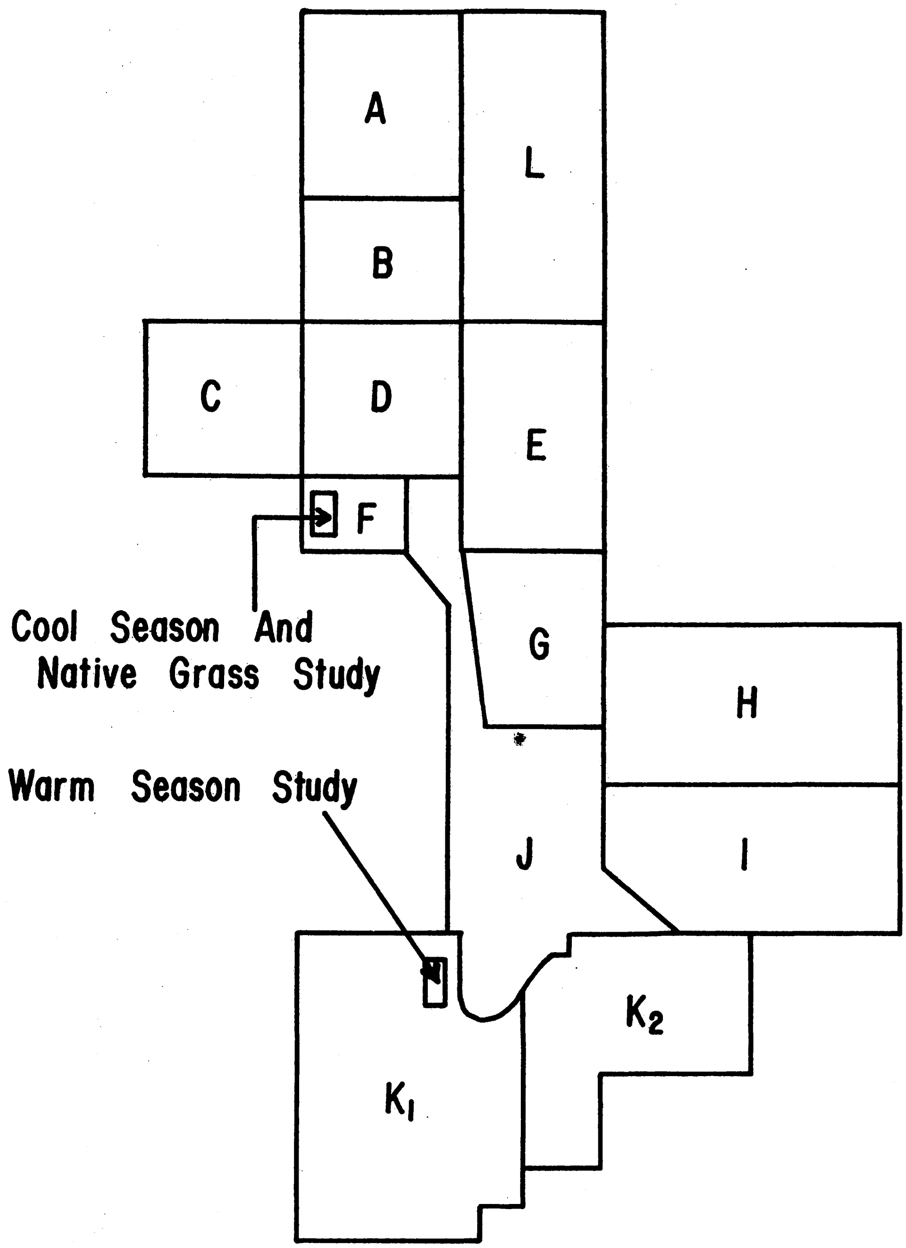

Figure 1. Map of Sarkeys Foundation Research and Demonstration Project and Study Site (Sec 7, 18, R12E, T8N) Two Miles East of Lamar, Oklahoma

Oklahoma on the Sarkeys Foundation demonstration site (Section 7 and Section 18, T.7N., R12E.). The study area lies on a Hector Hartsell soil series characterized by shallow to very shallow stony, loamy, and somewhat excessively drained soil. The slopes range from 5 to 30 percent and are easily erodeable when disturbed. These soils formed under oaks and tall grass from parent material weathered from acid sandstone and shale (Long, 1968). Soil test information has shown these soils to be very low in nitrogen and available phosphorus and moderate to low in potassium with a pH ranging from 5.4 to 5.5 (Table I). This site is representative of many other sites throughout the Ouachita Highland Resource Area of Eastern Oklahoma and Western Arkansas.

The native vegetation as described by Bruner (1931), is made up of blackjack (*Quercus marilandica* Muenchh.), post oak (*Q. stellata* Wing.), hickory (*Carya* spp. Nutt.), and an understory of secondary woody species. Important herbaceous species common to the area include big bluestem (*Andropogon gerardi* Vitman.), little bluestem (*A. scoparius* Michx.), indiangrass [*Sorghastrum nutans* (L.) Nash], switchgrass (*Panicum virgatum* L.), and broomsedge (*A. virginicus* L.).

Two different experiments are discussed in this report. One study was located in the K_1 Area on the Sarkeys Foundation demonstration site and was planted to three introduced warm season grasses. The second study was located in the F area. This site was planted to three cool season grasses and was also the site for the native grass study. Each study site location is shown in Figure 1.

TABLE I

SOIL TEST RESULTS FROM THE STUDY SITE BEFORE FERTILIZER TREATMENTS WERE APPLIED

Location	Lb/Acre			
	NO_3-N	P	K	pH
Warm Season Plots (K_1 Area)	<10	8	117	5.4
Cool Season Plots (F Area)	<10	11	200	5.5

Introduced Warm Season Species

Brush Control

The entire study area was aerially sprayed on June 5, 1973. A herbicide oil-water emulsion of 2,4-D [(2,4-dichlorophenoxy) acetic acid] and 2,4-DP [2-(2,4-dichlorophenoxy) propionic acid] was applied at one lb of 2,4-D and one lb of 2,4-DP/acre in a total spray volume of five gal/acre which consisted of 0.5 gallon diesel fuel, 0.5 gallon herbicide, and four gallons of water. The herbicide mixture was applied in a 40-foot spray swath. Soil moisture was excellent at the time of spraying. Relative humidity was 80 percent. Soil temperature at the six inch depth was 68 F. The wind was from the north at one mph.

Burning

The entire area was completely burned on April 5, 1973, two months prior to spraying. The leaf litter was in sufficient quantities and dry enough so that a controlled low fire removed most of the leaf litter present. The soil surface was moist at the time of the burn.

Design

A factorial of three species × seven fertility treatments in a randomized block experimental design with five replications was employed in this study (Table II). Each plot measured 10 × 25 feet. The treatments were three warm season grass species, Guymon bermudagrass [*Cynodon dactylon* (L.) Pers.], Plains bluestem [*Bothriochloa ischaenum* (L.) Keng.], and Morpa weeping lovegrass [*Eragrostis curvula* (Schrad.) Nees] at three levels of nitrogen, two levels of phosphorus and two

TABLE II

DESIGN OF WARM SEASON STUDY SHOWING FERTILIZER TREATMENTS AND GRASS SPECIES

Species	Treatment Number	Fertilizer Treatment (Lb/Acre)		
		N	P (P_2O_5)	K (K_2O)
Guymon Bermuda	1	0	0	0
	2	40	0	0
	3	80	0	0
	4	40	18 (40)	0
	5	80	18 (40)	0
	6	40	18 (40)	33 (40)
	7	80	18 (40)	33 (40)
Plains Bluestem	8	0	0	0
	9	40	0	0
	10	80	0	0
	11	40	18 (40)	0
	12	80	18 (40)	0
	13	40	18 (40)	33 (40)
	14	80	18 (40)	33 (40)
Morpa Weeping Lovegrass	15	0	0	0
	16	40	0	0
	17	80	0	0
	18	40	18 (40)	0
	19	80	18 (40)	0
	20	40	18 (40)	33 (40)
	21	80	18 (40)	33 (40)

levels of potassium. The fertilizer treatments applied were nitrogen at 0, 40, and 80 lb/acre, phosphorus at 0 and 18 lb/acre, and potassium at 0 and 33 lb/acre (Table II). Guymon bermudagrass is a temporary name given to this variety of bermudagrass for identification purposes only. This is an unreleased seeded variety which originated from Guymon, Oklahoma and is presently being tested for release.

Seeding and Fertilization

The seed and fertilizer were weighed and packed together in plastic sacks on June 4, 1973. The seeding rate for each species in the study was as follows: two lb/acre for bermudagrass, three lb/acre for weeping lovegrass, and five lb/acre for Plains bluestem. On June 6, 1973, the mixture of seed and fertilizer was applied to the plots by hand broadcasting. Soil moisture at the time of seeding was good, but precipitation for the following two months was below normal for that time of the season (Appendix Table XII).

Evaluation

Success of the seedling stand was evaluated for the first time on September 28, 1973, and again on June 25, 1974. In both evaluations estimates of the success of the stand were made by using frequency of occurrence in a one foot square quadrat. Readings were taken with a one foot square quadrat with 20 random readings per plot. Only the presence of the species was recorded in each reading. If the species was present within the quadrat, regardless of its abundance, it was given a value of one.

The author made visual estimates of the percent native weedy species present in this study on July 10, 1974. The species present in each replication were estimated by sight and the average of these five replications were summarized (Table III).

Introduced Cool Season Species

Brush Control

The entire study area was aerially sprayed on June 8, 1970. A herbicide oil-water emulsion of 1.64 lb of Silvex [2-(2,4,5-Trichlorophenoxy) propionic acid] and 0.8 lb of Picloram (4-amino-3,5,6-Trichloropicolinic acid) per acre was used. Total spray volume was 4.1 gal/acre. A 40-foot spray swath was used. Soil moisture conditions were excellent at the time of spraying. The soil temperature at the six inch depth was 67 F. The wind was from the south at one mph.

Burning

The study area was burned on March 24, 1970, and again on March 21, 1972. On August 20, 1973, the area was burned again approximately one month prior to seeding and fertilizing of the cool season plots. During each burn the soil surface was moist. At the time of the third burn the study area contained large amounts of broomsedge, little bluestem, and other native warm season grasses. Only small amounts of leaf litter were present. The dry grass in the study area was almost completely burned by the fire. The burn was made about 10:00 a.m. with the relative humidity at 57 percent, air temperature at 83 F, and a wind velocity that varied from four to 10 mph.

TABLE III

BOTANICAL COMPOSITION OF WARM SEASON GRASS PLOTS, JULY 10, 1974
OCCULAR ESTIMATE OF PERCENT OF TOTAL VEGETATION

Common Name	Species Scientific Name	Percent
Broomsedge	Andropogon virginicus L.	22.0
Marestail	Conyza canadensis	18.0
Fireweed	Epilobium angustifolium	12.0
Pokeberry	Phytolacca americana L. (P. decandra L.)	8.0
Little Bluestem	Andropogon scoparius Michx.	7.0
Nutgrass	Cyperus spp. L.	5.0
Panicum	Panicum spp. L.	4.6
Heath Aster	Aster ericoides L.	4.6
Blackeyed Susan	Rudbeckia hirta L.	3.8
Catclaw Sensitive Briar	Schrankia muttallii (D.C.) Standl.	3.2
Crabgrass	Digitaria sanguinalis (L.) Scop.	2.2
Big Bluestem	Andropogon gerardi Vitman	1.4
Mint	Mentha arvensis L.	1.4
Switchgrass	Panicum virgatum L.	0.6
Pussytoes	Antennaria spp. Gaertn.	0.6
Foxtail	Alopecurus spp. L.	0.4
Groundcherry	Physalis spp. L.	0.4
Annual Ragweed	Ambrosia artemisiifolia L.	0.4
White Snakeroot	Eupatorium rugosum Houtt.	0.4
Sowthistle	Sonchus spp. L.	0.2
Lambsquarter	Chenopodium album L.	0.2
Miscellaneous		3.6

Design

A complete factorial of three species × four nitrogen treatments × two phosphorus treatments in a randomized block experimental design with five replications was employed in this study (Table IV). The plot size was 10 × 25 feet. The grass species were Kentucky 31 tall fescue (*Festuca arundinacea*, Schreb.), Kenhy tall fescue (a Festuca × *Lolium* cross), and Jose tall wheatgrass [*Agropyron elongatum*, (Host) Beauv.].

Seeding and Fertilization

The seed and fertilizer were weighed and packed together in plastic bags on September 18, 1973. A seeding rate of 15 lb/acre of pure live seed for each of the three species was used. On September 21, 1973, the plots in two replications were broadcast seeded and fertilized with the previously prepared mixture of seed and fertilizer. On October 18, 1973, the remaining three replications in the study were seeded and fertilized using the same procedures. At the time of seeding for all replications the soil moisture appeared to be excellent due to above normal rainfall for the period (Appendix Table XII). A blanket application of 300 lb of 23-11-11 (N-P_2O_5-K_2O) fertilizer was aerially applied over all plots on September 7, 1974.

Evaluation

On December 14, 1974, the success of seedling stand establishment of the three cool season grass species was made. The technique for evaluating the stand was a frequency of occurrence in a one foot square quadrat, with 20 random readings per plot. Only the presence of a

TABLE IV

DESIGN OF COOL SEASON STUDY SHOWING FERTILIZER TREATMENTS AND GRASS SPECIES

Species	Treatment Number	Fertilizer Treatment (Lb/Acre) N	P (P_2O_5)
Kentucky-31 Tall Fescue	1	0	0
	2	20	0
	3	40	0
	4	80	0
	5	0	22 (50)
	6	20	22 (50)
	7	40	22 (50)
	8	80	22 (50)
Kenhy Tall Fescue	9	0	0
	10	20	0
	11	40	0
	12	80	0
	13	0	22 (50)
	14	20	22 (50)
	15	40	22 (50)
	16	80	22 (50)
Jose Tall Wheatgrass	17	0	0
	18	20	0
	19	40	0
	20	80	0
	21	0	22 (50)
	22	20	22 (50)
	23	40	22 (50)
	24	80	22 (50)

species was recorded for each reading. If the species was present within the quadrat, regardless of its abundance, it was given a value of one.

On July 9, 1974, the percent of native grasses present in the cool season plots was estimated using a point frame with 10 points. The frame was set down randomly one time in each plot, and the botanical composition of the entire study area determined (Table V).

Native Warm Season Species

The response of native grasses to fertilizer was evaluated on the seeded cool season plots. Therefore, brush control, burning, and fertility dates and methods were the same as those used in the cool season study. This evaluation was possible because the previously fall planted cool season species had made insignificant growth by the following June when native grass evaluations were made.

Yield

Yield response of native grass was estimated June 28, 1974, using an 18 × 36 inch quadrat that was randomly placed in each plot. All plots were clipped at a height of two inches above the ground surface. The samples were oven dried and weighed.

Crude Protein and Phosphorus

Oven dried samples of the native grass were subjected to crude protein and phosphorus analysis. Samples were ground through a one mm screen in a Wiley mill. The crude protein was determined by the Micro-Kjeldhal method, as described in Official Methods of Analysis

TABLE V

BOTANICAL COMPOSITION OF COOL SEASON GRASS PLOTS, JULY 9, 1974, REPORTED AS PERCENT OF TOTAL VEGETATION

Common Name	Species Scientific Name	Percent
Little Bluestem	*Andropogon scoparius* Michx.	33.5
Broomsedge	*Andropogon virginicus* L.	31.8
Tall Fescue Tall Wheatgrass	*Festuca arundinacea* Schreb. *Agropyron elongatum* (Host) Beauv.	13.4
Nutgrass	*Cyperus* spp. L.	9.3
Pussytoes	*Antennaria* spp. Gaertn.	2.4
Miscellaneous Forbs		2.6
Big Bluestem	*Andropogon gerardi* Vitman	1.7
Panicum	*Panicum* spp. L.	1.7
Switchgrass	*Panicum virgatum* L.	1.2
Indiangrass	*Sorghastrum nutans* (L.) Nash	0.6
Dock	*Rumex* spp. L.	0.6
Miscellaneous grasses		0.6
Bitter Sneezeweed	*Helenium tenuifolium* Nutt.	0.6

(A.O.A.C., 1970). Phosphorus content in the samples was determined by the Vanadate procedure (Jackson, 1958).

Data Analysis

The data collected in each study were subjected to an Analysis of Variance in order to determine differences among treatments. Differences between treatments were tested by the least significant difference (LSD) test (Steel and Torrie, 1960).

CHAPTER IV

RESULTS AND DISCUSSION

Establishment of Warm Season Species

The seed and fertilizer were applied on the warm season plots two months after the area was burned and one day before the herbicide was aerially applied. Good contact between the soil and seeds was obtained because a sufficient amount of leaf litter was removed by burning. Soil moisture was good at the time of seeding. Leaves had begun falling from the sprayed hardwoods by the time that young seedlings began emerging.

Two evaluations were made of the warm season plots to determine success of stand establishment as affected by fertilizer treatments. Determinations were made by the presence or absence of a grass species in 20 one foot square quadrats. The Coefficients of Variation for the first and second evaluations were 45 and 43 percent, respectively.

Effects of Fertilization

In the first evaluation, September 28, 1973, nearly four months after seeding, no significant differences were found in establishment of grass species due to different fertilizer treatments of nitrogen, phosphorus, or potassium. In the later evaluation made on June 25, 1974, slightly over 12 months after the seeding date, phosphorus gave a significant positive effect on grass establishment over the check plots when applied with higher rates of nitrogen. In the second evaluation, nitrogen applied on separate plots at 40 and 80 lb/acre was shown to increase establishment over the check plots with no nitrogen where ($P < .10$). All nitrogen treatments applied in combination with phosphorus and potassium gave significant increases over the check plots with no fertilizer. Potassium applied at 33 lb/acre did not significantly increase establishment over treatments without potassium. Data indicating the results of fertilizer effects on establishment of warm season grass for both dates of evaluation are shown in Table VI.

The lack of significance due to fertilizer treatments in the first evaluation ($P < .05$) was attributed to low soil moisture following the seeding date and hence slow seedling growth and development, making it difficult to detect such differences. In the later evaluation the young seedlings had time to make considerable growth, develop, and make use of the available soil nutrients that were applied. As a result, differences in establishment due to the effects of fertilizer treatments were detected.

Species Response

There was not a significant species × fertilizer interaction indicated in either evaluation, so it was assumed that all three species tested in the study reacted similarly to the effects of fertilizer.

In the first evaluation in September, all three species proved significantly different in terms of frequency of occurrence (Figure 2). Weeping lovegrass was found to be the most successful of the three species tested. It occurred in 62 percent of the sample quadrats.

TABLE VI

WARM SEASON GRASSES, FREQUENCY OF OCCURRENCE, FOR EACH FERTILIZER TREATMENT IN 20 ONE FOOT SQUARE QUADRATS PER PLOT

Fertilizer lb/acre	Frequency of Occurrence Bermuda Grass	Plains Bluestem	Weeping Lovegrass	Mean Success
N P K		September 28, 1973		
0- 0- 0	22	52	40	38 ns[a/]
40- 0- 0	48	46	65	53 ns
80- 0- 0	34	60	67	54 ns
40-18- 0	30	56	57	48 ns
80-18- 0	29	47	69	48 ns
40-18-33	47	46	75	56 ns
80-18-33	54	49	60	54 ns
N P K		June 25, 1974		
0- 0- 0	15	45	44	35 c[b/]
40- 0- 0	16	37	74	42 bc
80- 0- 0	23	35	83	47 bc
40-18- 0	24	44	71	46 bc
80-18- 0	46	51	76	58 ab
40-18-33	42	47	79	56 ab
80-18-35	54	68	85	69 a

[a/] Non significant at the (.05 level).

[b/] Values within the fertilizer treatments followed by the same letter are not significantly different from each other at the (.05 level) according to the LSD test.

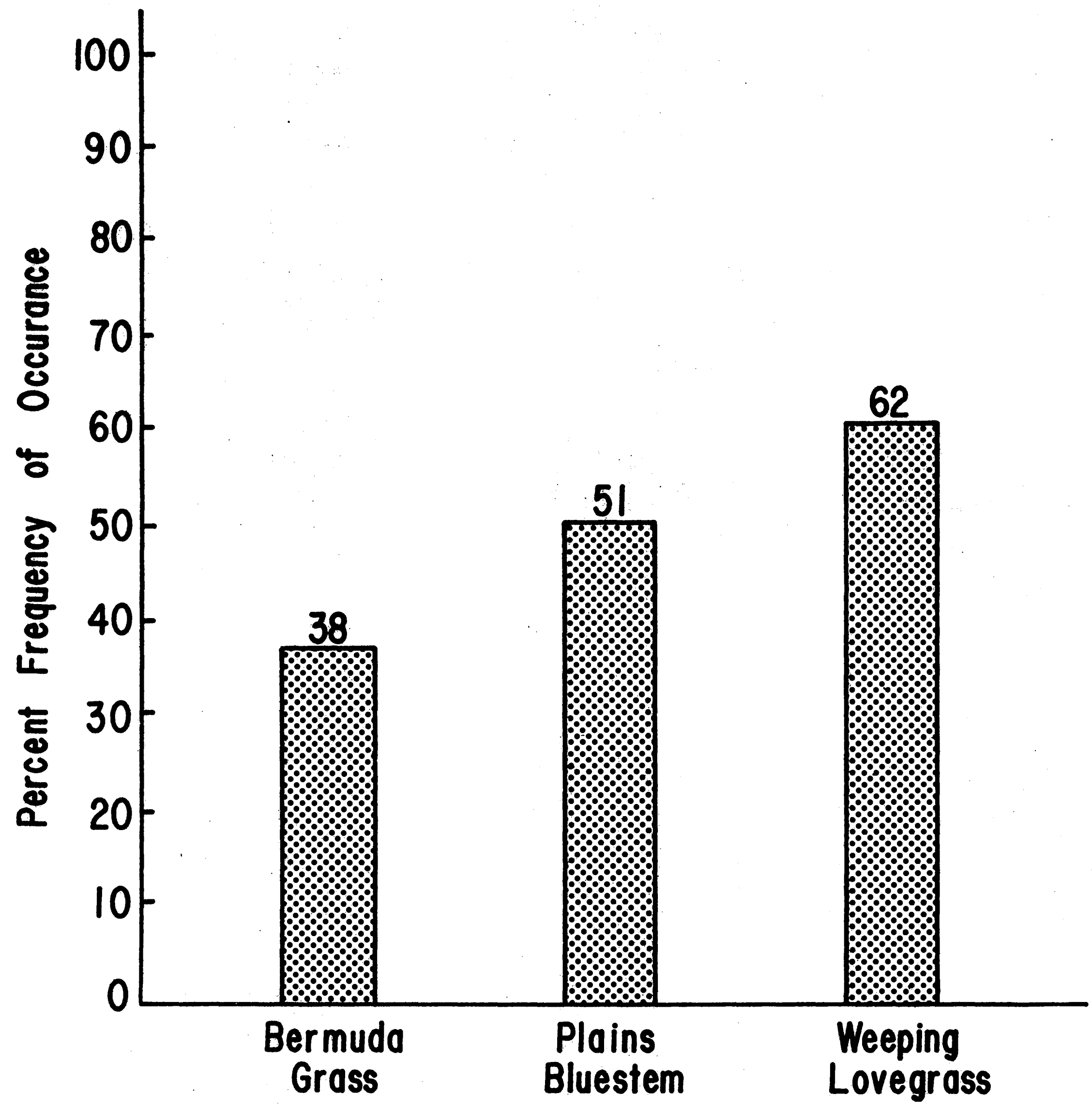

Figure 2. Warm Season Grasses, September 28, 1973, Frequency of Occurrence in 20 One Foot Square Quadrats Averaged Over all Fertility Treatments

Plains bluestem followed with 51 percent occurrence in all quadrats. Bermudagrass was the least successful with 38 percent occurrence in all quadrats. The June evaluation, 12 months later, was characterized by larger and more firmly established plants. This evaluation, however, gave results very similar to the previous one (Figure 3). Weeping lovegrass was again most successful (73 percent), followed by Plains bluestem (47 percent), and bermudagrass (31 percent). When growth habits and characteristics of each grass species were taken into consideration, the stand obtained in this study was considered successful when adequate amounts of fertilizer were applied.

Among the three species tested, bermudagrass was the least successful in establishment. Given a longer growth period and adequate fertilizer this grass species may have the greatest potential for establishment on rough areas because of its ability to spread rapidly by rhizomes. Its resistance to cold and native grass competition are important considerations that should not be overlooked. More detailed research will be needed in order to properly evaluate the potential of this species. Weeping lovegrass could be established in these rough areas and findings by Loveland (1972) are comparable to the results obtained in this study. The value of this grass species in rough areas is questionable because good management, which consists of mowing, burning, and rotation grazing may not be feasible on rough inacessible areas. Lovegrass is a bunchgrass and this growth habit does not readily allow the initially established plants to spread rapidly except by natural reseeding which is questionable in this area. Therefore, seeded areas which are not initially successful by the often variable aerial applications may not later fill in with this species. Plains

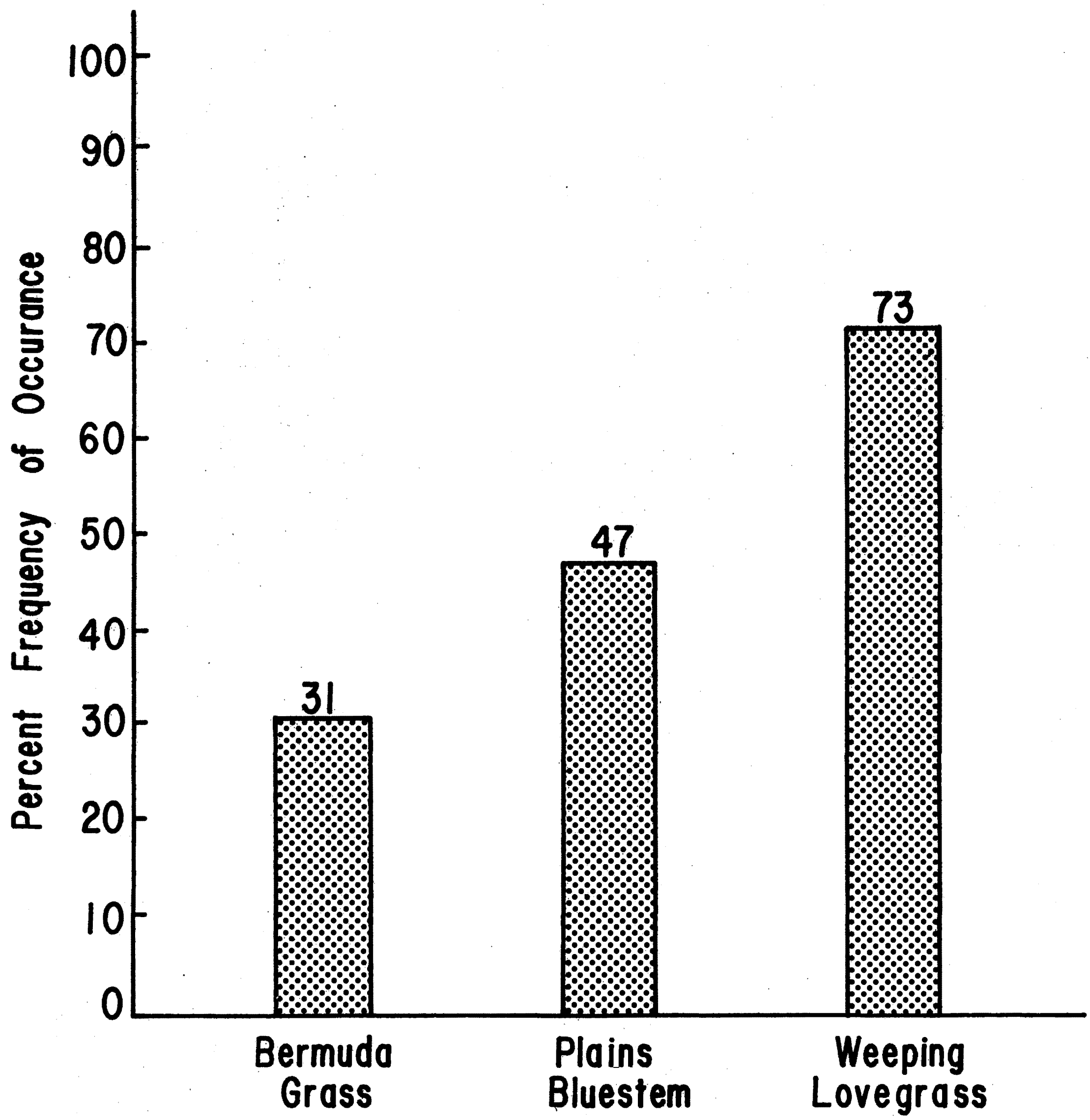

Figure 3. Warm Season Grasses, June 25, 1974, Frequency of Occurrence in 20 One Foot Square Quadrats Averaged Over All Fertility Treatments

bluestem is palatable, reasonably easy to establish, and has been described as having weedy characteristics by some. Therefore, this grass species may offer promising possibilities which should be considered when converting brushland into warm season pasture.

Establishment of Cool Season Species

The seed and fertilizer for the cool season grass plots was applied on two different dates. On September 21, 1973, two replications were seeded, and October 18, 1973, the remaining three replications were seeded. These seeding dates followed one and two months, respectively, after the last burning date. The woody vegetation was aerially sprayed three years earlier. Therefore, the effects of the burn were not only to remove soil litter, but to also weaken the dense stand of native grass on the study area. The burn did remove most of the top growth from the native grasses, but by the last seeding date most of the native grass had acquired six to eight inches of new top growth. Evaluation of the study was made the following year about 14 months after seeding. There was not sufficient growth of the young seedlings on any plot to permit an earlier evaluation. The study was at one time considered a complete failure because of the extremely slow growth and apparent absence of plants the first fall and spring following seeding. Only after aerially applying 300 pounds of 23-11-11 (N-P_2O_5-K_2O) fertilizer on September 7, 1974, did it become apparent that an evaluation of the seeded grass species could be made. Determinations of stand success were made by the presence or absence of a given plant species in 20 one foot square quadrats. Coefficient of Variation for the evaluation was 31 percent.

Effects of Fertilization

Analysis of data revealed no significant differences in seedling establishment due to nitrogen and phosphorus treatments (Table VII). Although statistically significant only where ($P < .10$), the phosphorus seemed to have an apparent negative effect on the establishment of all three cool season grass species (Table VIII). The mean frequency of occurrence averaged over the three species with 22 pounds of phosphorus was 52 percent, and no phosphorus was 64 percent (Figure 4).

The lack of significance due to variable rates of nitrogen and phosphorus fertilizer was attributed to the date of evaluation (14 months after application of fertilizer) and the resultant competition for nutrient uptake by the dense stand of native grasses in the study area. During this period, the native grasses, which were already established may have out competed the seeded grasses for nitrogen and phosphorus. This is substantiated by the figures found in Tables VIII and IX showing response of native grass to applied nitrogen and phosphorus. Two months before evaluation, a blanket application of 300 pounds of 23-11-11 ($N-P_2O_5-K_2O$) fertilizer was aerially applied to all plots. This also would help erase any differences due to initial fertilizer levels.

Species Response

There was not a significant species × fertilizer interaction indicated in analysis of the cool season data. Therefore, it was assumed that establishment of all three species reacted similar to the effects of fertilizer. Kenhy tall fescue and Kentucky-31 tall fescue proved

TABLE VII

COOL SEASON GRASSES, DECEMBER 14, 1974, FREQUENCY OF OCCURRENCE FOR EACH FERTILIZER TREATMENT IN 20 ONE FOOT SQUARE QUADRATS PER PLOT

Fertilizer lb/acre	Frequency of Occurrence			
	Tall Wheatgrass	K-31 Fescue	Kenhy Fescue	Mean Success
N P				
0-0	45	80	63	63 ns[a/]
20-0	47	72	66	62 ns
40-0	53	74	65	64 ns
80-0	56	67	78	67 ns
0-22	40	58	36	45 ns
20-22	24	54	65	48 ns
40-22	26	67	68	54 ns
80-22	36	76	69	60 ns

[a/] Non significant at the (.05 level).

TABLE VIII

COOL SEASON GRASSES, DECEMBER 14, 1974, FREQUENCY OF OCCURRENCE AT EACH NITROGEN AND PHOSPHORUS TREATMENT

	Fertilizer lb/acre	Frequency
Nitrogen		
	0	63a[1/]
	20	62a
	40	64a
	80	67a
Phosphorus		
	0	64a[2/]
	22 (50 P_2O_5)	52b

[1/] Values within each fertilizer treatment followed by the same letter are not significantly different at the .05 level.

[2/] These treatments were significantly different at the .10 level.

TABLE IX

NATIVE GRASS DRY MATTER PRODUCTION JUNE 25, 1974, AS INFLUENCED BY NITROGEN AND PHOSPHORUS

Fertilizer lb/acre N P	Yield lb Dry Matter/Acre
0-0	2,444 cd[1/]
20-0	2,588 cd
40-0	2,691 bc
80-0	2,492 cd
0-22	2,223 d
20-22	2,702 bc
40-22	3,114 ab
80-22	3,316 a

[1/]Values within fertility levels followed by the same letter are not significantly different from each other at the .05 level.

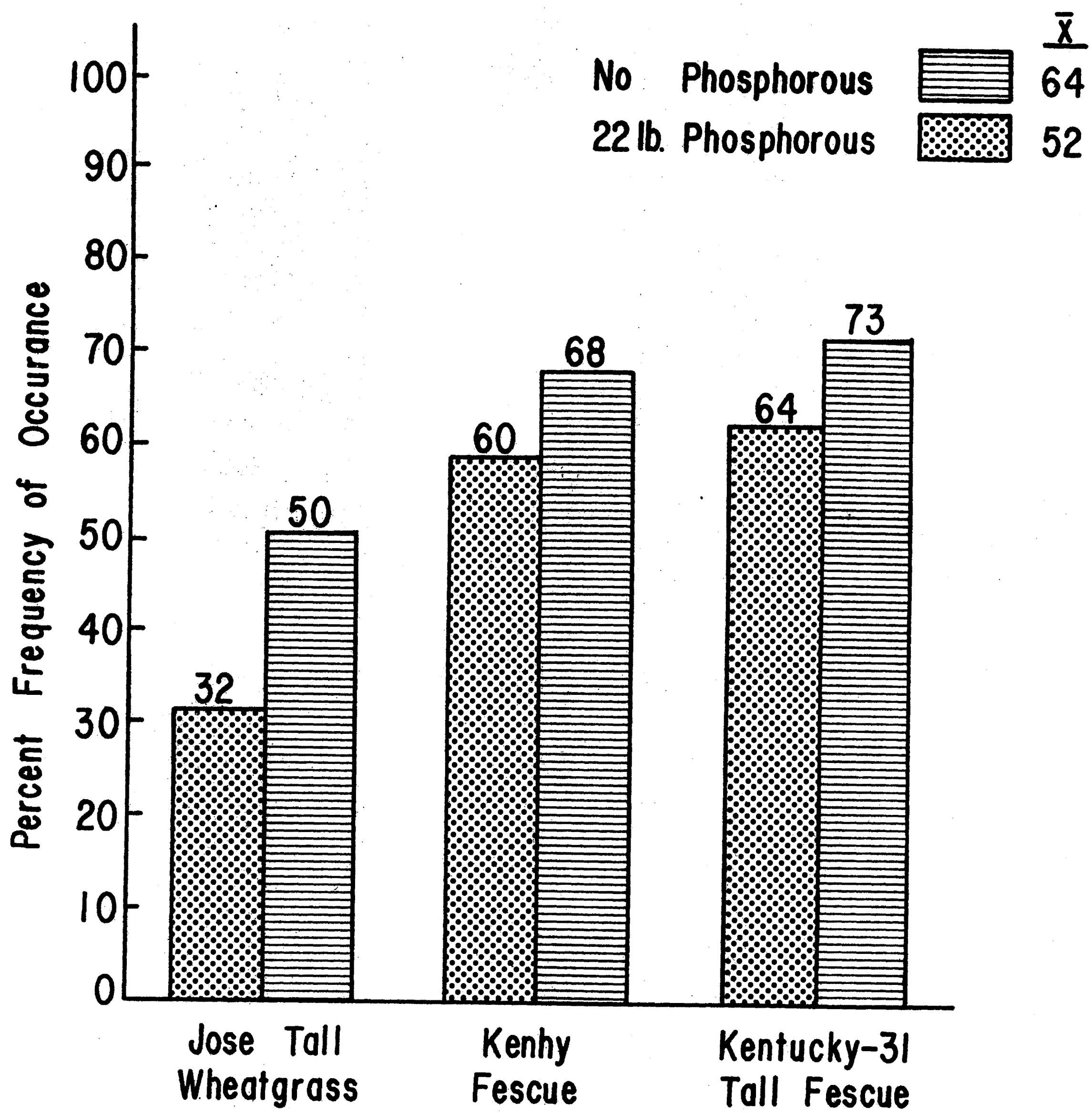

Figure 4. Phosphorus Effects on Establishment of Three Fall Seeded Cool Season Grass Species

significantly better ($P < .05$) than Jose tall wheatgrass in this study. There was no difference detected between the two varieties of tall fescue (Figure 5). Kentucky-31 and Kenhy tall fescue were the most successful species with 69 and 64 percent frequencies of occurrence, respectively. Jose tall wheatgrass had a 41 percent frequency of occurrence. The percentage of occurrence for the fescues was high enough to be considered successfully established stands, although establishment was slow.

Effects of Seeding Date

Differences between seeding dates of the cool season species are not a statistically valid test since each of the seeding dates were not replicated an equal number of times. A comparison of the data seems worthy of mention. The mean frequency of occurrence averaged over all three species was 43 percent for the September seeding and 67 percent for the October seeding (Figure 6). The apparent difference in success was attributed mainly to the effects of native grass competing for soil moisture, and the warmer air temperatures, which resulted in a less favorable seedling environment with the earlier seeding date. With the later seeding date, the native grass growth was soon stopped by frost. This fact, plus cooler temperatures, would provide a more suitable seedbed for the young seedlings.

These data seem to indicate that October is a better date than September for seeding cool season grasses into a stand of native grass. Further research may indicate that dates later than October or even spring will be more suitable for establishing cool season grass species in native grass stands in rough terrain.

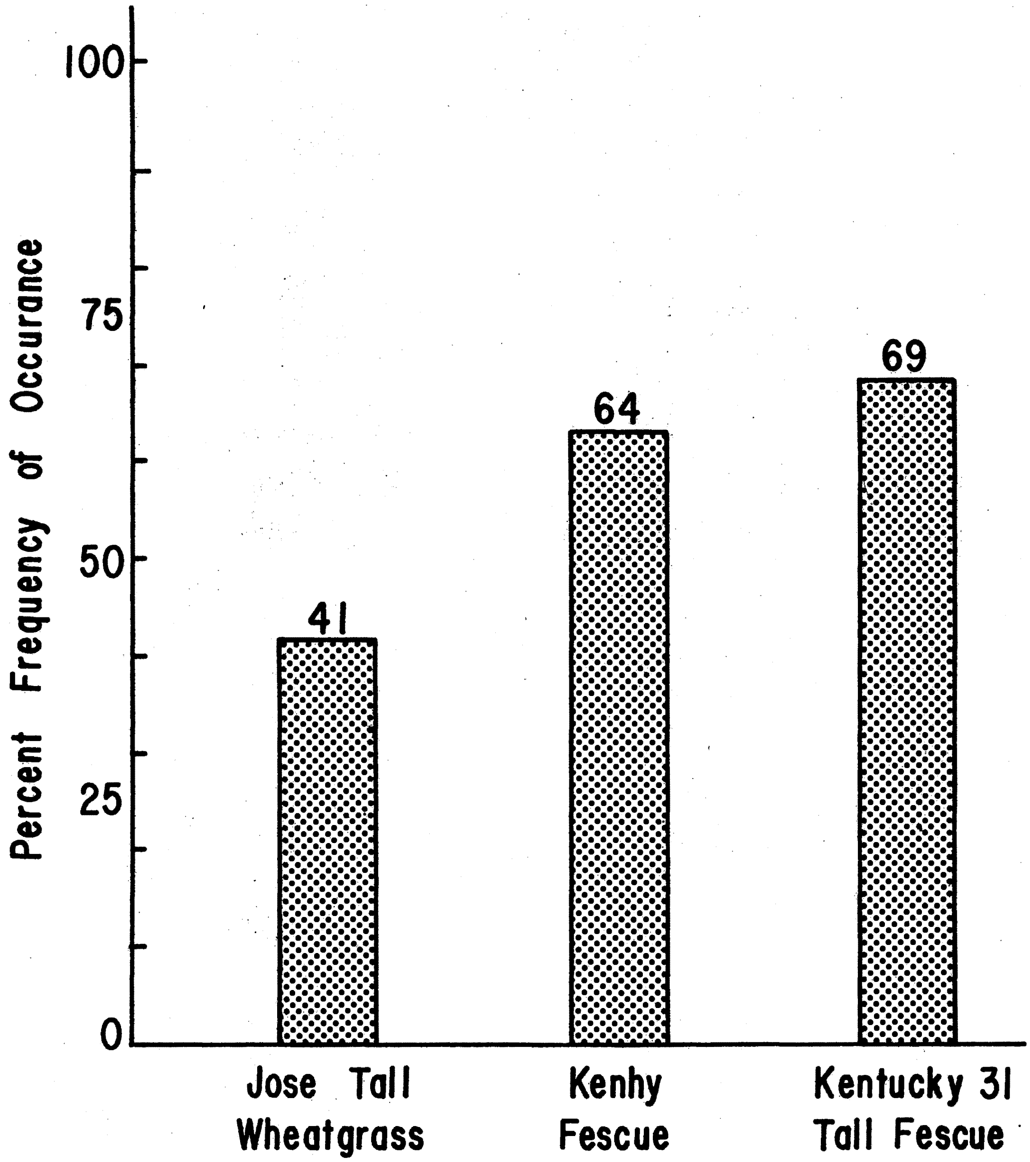

Figure 5. Cool Season Grasses, Frequency of Occurrence in 20 One Foot Square Quadrats, Averaged Over All Fertility Treatments

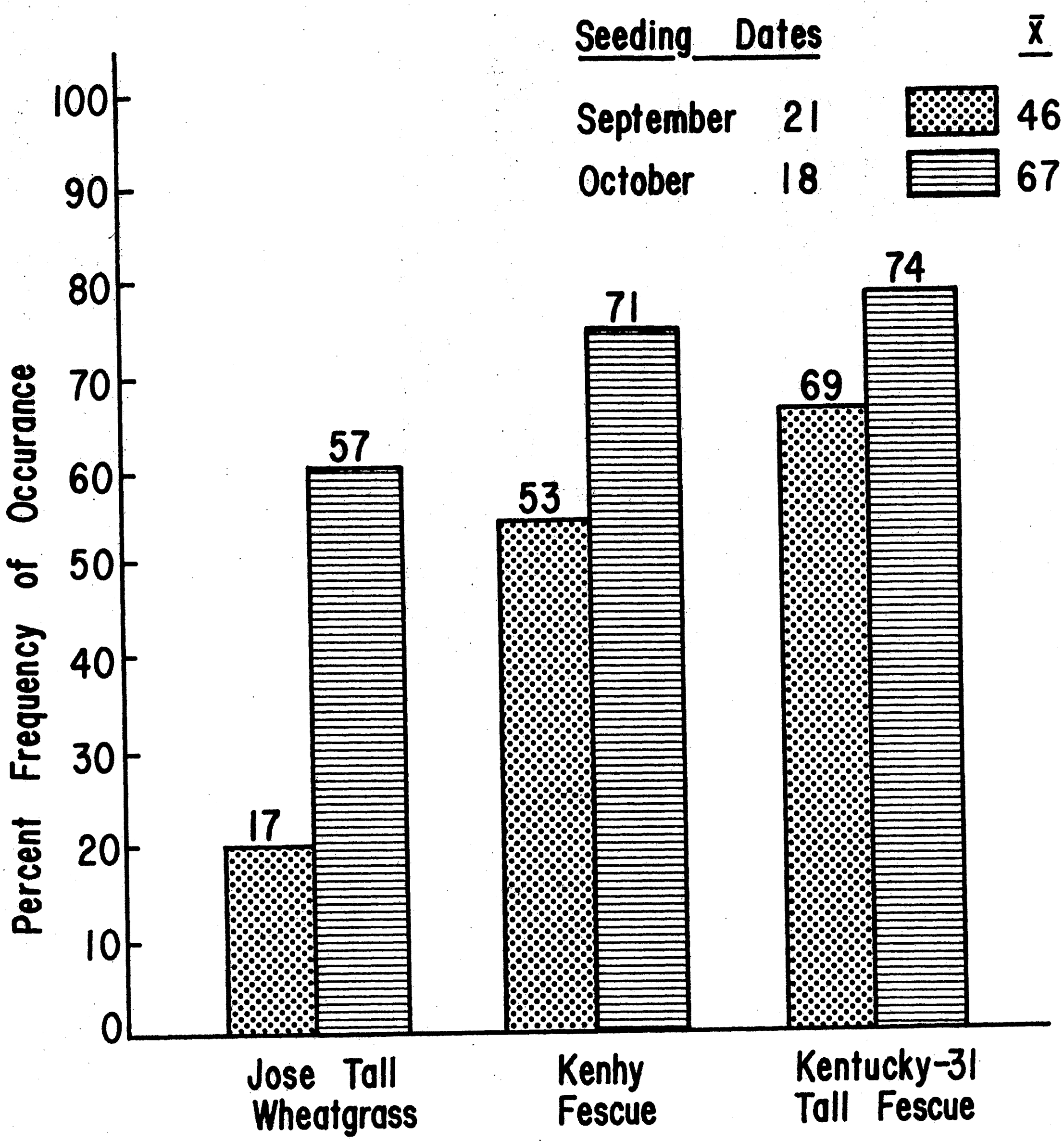

Figure 6. Comparison of September and October Seedings on Establishment of Cool Season Grass in an Established Stand of Native Grass

Native Warm Season Species

The native grass species were evaluated on the cool season grass plots. This was possible because the previously fall planted cool season species made insignificant growth by the following June when evaluations of native grass were made. The native grass samples were clipped on June 28, 1974. The Coefficients of Variation for yield, crude protein, and phosphorus data were 13, 15 and 21 percent, respectively.

Effects of Fertilization on Yield

Even with a low Coefficient of Variation, 13 percent, there was no significant difference in yields from zero to 80 lb of nitrogen/acre without phosphorus (Tables IX and X). Phosphorus applied at 22 lb/acre without nitrogen gave no significant increase in yield over no phosphorus. A significant nitrogen × phosphorus interaction occurred in the study. When nitrogen fertilizer was applied with 22 lb phosphorus/acre, yields were significantly increased over the check plots. A possible explanation for this interaction is that both elements were present in such small amounts that they became limiting factors to plant growth as indicated by previous soil tests (Table I). When either nutrient was applied alone the other nutrient was limiting and acted to keep yields lower. When both nutrients were present, the limiting factor was removed and an increase in dry matter production was observed.

Effects of Fertilization on Crude Protein

Results of the analysis for percent crude protein at each level of fertilization are shown in Figure 7. Analysis of variance revealed

TABLE X

NATIVE GRASS DRY MATTER PRODUCTION, JUNE 25, 1974, AT EACH LEVEL OF NITROGEN AND PHOSPHORUS FERTILIZER

	Fertilizer lb/acre	Yield lb Dry Matter/acre
Nitrogen		
	0	2,444 a[1/]
	20	2,588 a
	40	2,691 a
	80	2,492 a
Phosphorus		
	0	2,554 b
	22 (50 P_2O_5)	2,839 a

[1/] Values within each fertilizer treatment followed by the same letter are not significantly different at the .05 level.

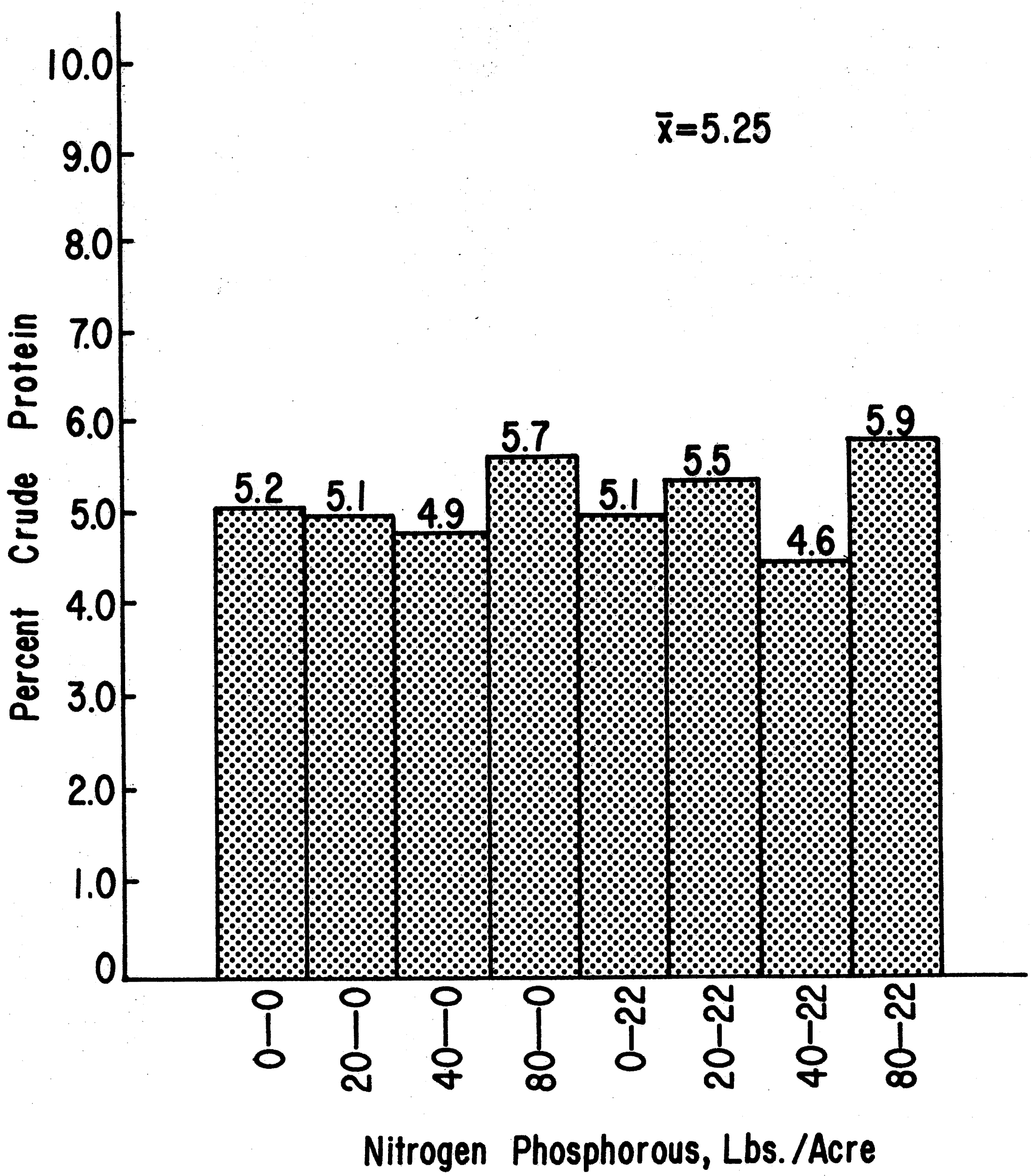

Figure 7. Crude Protein Content of Native Grass at Each Level of Nitrogen and Phosphorus (P) Fertilizer

no significant differences in crude protein to various nitrogen and phosphorus treatments, with a Coefficient of Variation of 15 percent. The mean crude protein content of native grass for all levels of nitrogen and phosphorus was 5.25 percent.

The range from 4.6 to 5.9 percent crude protein suggests the low quality of the native grass as forage for livestock consumption.

Effects of Fertilization on Phosphorus

Phosphorus content of the native grass forage was significantly increased by the addition of 22 lb of phosphorus/acre (Figure 8). The mean phosphorus content was 0.06 percent without an application of phosphorus and 0.10 percent with an application of 22 lb of phosphorus/acre. When nitrogen and phosphorus were applied in combination, each increment of added nitrogen brought about a decrease in the phosphorus content of the native grass. This appeared to be a dilution effect related to the increased forage production from each additional nitrogen increment (Figure 8).

The highest content of phosphorus for any treatment was 0.12 percent. This level is far less than the minimum requirements for beef cattle which ranges from 0.16 to 0.43 percent (National Academy of Sciences, 1970).

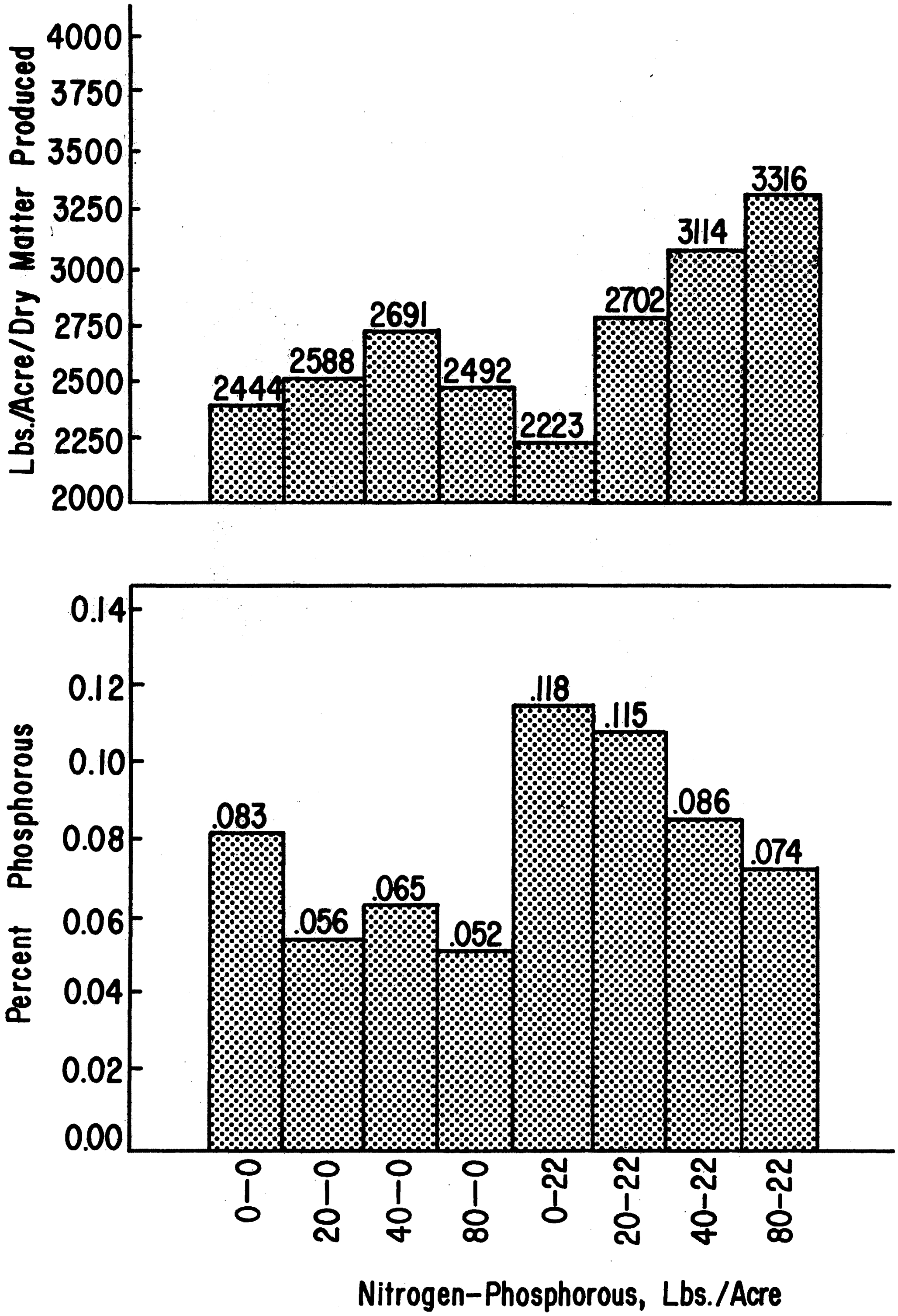

Figure 8. The Relationship Between Forage Produced (Dry Weight) and the Phosphorus (P) Content of the Native Grasses

CHAPTER V

SUMMARY AND CONCLUSIONS

The establishment of warm and cool season grass species was evaluated on a study area within the Ouachita Highlands Resource area of Eastern Oklahoma. This study attempted to define techniques for two questions; (1) Can warm season pastures be successfully established on rough land in Eastern Oklahoma following control of brush using herbicides and burning? (2) Can cool season pastures be successfully established on a site where hardwood brush control has been practiced two or more years previously and native grass has been allowed to become established? In both studies the areas were control burned to prepare the seedbed prior to seeding.

Warm Season Study

This experiment tested the establishment and growth of three grass species, bermudagrass, weeping lovegrass, and Plains bluestem, in response to seven fertilizer treatments. Seeding and fertilizing were done June 6, 1973, one day before aerial spraying for brush control.

Four months after seeding and fertilizing there were no differences in seedling establishment as a result of different fertilizer treatments. However, 12 months after seeding and fertilizing the higher fertility rates had significantly increased stand establishment. Weeping lovegrass frequency of occurrence was 68 percent, followed by Plains bluestem at 49 percent, and bermudagrass at 35 percent. Experience has shown that weeping lovegrass is difficult to manage on such rough land and thinned stands do not thicken. Bermudagrass may have the best potential to thicken since it spreads vegetatively by rhizomes and stolons.

Cool Season Study

The three grass species; Kentucky-31 tall fescue, Kenhy fescue, and Jose tall wheatgrass; were evaluated using four levels of nitrogen and two levels of phosphorus fertilizer.

Nitrogen fertilizer had no significant effect on stand establishment, but phosphorus had a negative effect ($P < .10$) on stand establishment. This was not a clean seedbed, but one in a full recovery stand of native grass following brush control three years previously. The possible effect of the phosphorus in causing greater competition to the cool season grasses from native grass is shown in the native grass study.

Grass establishment was very slow and only after aerially applying an additional 300 lb of 23-11-11 ($N\text{-}P_2O_5\text{-}K_2O$) fertilizer one year later over all plots did the cool season species make enough growth to permit an evaluation of the study for stand success. Kentucky-31 tall fescue frequency of occurrence was 69 percent, followed by Kenhy fescue at 64 percent, and Jose tall wheatgrass at 41 percent.

Date of seeding had a pronounced effect on establishment of the cool season species. October appeared to be a better date for seeding than the earlier September date for all three species.

Native Grass Study

The response of native grasses to fertilizers used in seeding the cool season grass study was evaluated. Production of native grasses increased only when both nitrogen and phosphorus were applied in combination. Application of nitrogen fertilizer did not increase the crude protein content of the native grass. Applications of phosphorus increased the phosphorus content of the native grass, but applications of nitrogen decreased the phosphorus content of the forage. This decrease appeared to be related to increased forage growth that resulted from nitrogen and phosphorus fertilization. At all rates of fertilization the crude protein and phosphorus content of the native grass was very low.

Results from investigations carried out in this study indicate that botanical composition of brush covered land of the Ouachita Highlands Resource area can be successfully manipulated for production of quality introduced grasses for livestock. Establishment of these grasses may be relatively slow.

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TABLE XI

AVERAGE MONTHLY TEMPERATURES FROM HOLDENVILLE, OKLAHOMA (20 MILES WEST OF THE STUDY AREA)

Month	Average Monthly Temperatures (°F) 1973	1974	Departure From Normal* 1973	1974
January	37.3	39.2	-3.5	-0.6
February	42.3	48.2	-2.4	+3.7
March	56.0	58.6	+4.2	+7.6
April	58.0	63.0	-4.1	+0.3
May	68.4	73.0	-1.2	+3.2
June	75.2	74.1	-3.2	-3.7
July	80.6	83.7	-2.3	+1.3
August	80.1	80.0	-2.8	-2.2
September	73.7	66.3	-1.9	-8.3
October	66.3	65.2	+1.3	+0.6
November	55.7		+4.4	
December	43.7		+0.1	
Annual Mean Temperature	61.4		-1.0	

*1973 temperature normal is based on the period from 1931-1960. The 1974 temperature normal is based on the period from 1941-1970.

TABLE XII

MONTHLY PRECIPITATION RECEIVED AT HOLDENVILLE, OKLAHOMA (20 MILES WEST OF THE STUDY AREA)

Month	Precipitation (Inches) Received in		Departure From Normal*	
	1973	1974	1973	1974
January	3.40	0.90	+1.38	-.68
February	1.80	1.25	-0.70	-.82
March	5.47	1.63	+2.41	-1.10
April	6.20	10.35	+1.93	5.87
May	3.98	3.45	-2.36	-2.96
June	7.20	4.86	+1.97	0.09
July	1.85	0.42	-2.12	-3.75
August	2.05	2.07	-1.05	-0.82
September	7.30	4.75	+3.55	0.55
October	4.32	5.55	+1.06	1.84
November	7.15		+4.74	
December	1.55		-0.75	
Total	52.27		+10.06	

*Normal for 1973 year precipitation is based on the period from 1931-1960. The 1974 precipitation normal is based on the period from 1941-1970.

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